LRPT bands is unknown. If they are planning to vacate these bands, additional spectrum may be available on an exclusive basis. This would significantly improve availability and capacity over that computed here. It is believed there currently are three active Russian MetSats, Meteor 3-5 (137.850 MHz - ATP signal), OKEAN 1-7 (137.400 MHz - ATP signal), and SICH-1 (137.400 MHz - ATP signal).

In using Figure 2 to interpret the availability when using the TIP channels, it is assumed the TIP signal is on continuously. It's usage when not in-view of a CDA station is not clear. If this transmission ceases when not in-view of a CDA station, then the potential availability increases dramatically except around CDA stations. These calculations assume a 5° elevation coverage footprint for the MetSats to a 0° horizon coverage contour for calculating the exclusion zone for Leo One USA transmissions. The Leo One USA communications coverage is computed for an elevation angle of 15°. Since Leo One USA is the largest Little LEO constellation, other Little LEO systems should experience less reduction in availability than Leo One USA.

Leo One USA requires eight 25-kHz downlink subscriber channels (200 kHz) and three 50-kHz gateway channels. The total bandwidth requirements for the downlinks is 350 kHz of spectrum. The shared use of the LRPT bands provides 300 kHz of somewhat exclusive spectrum (except for China's FY-1B) until 2002; the shared use of the TIP bands could provide an additional 120 kHz which would then meet Leo One USA's requirements most of the time[3].

If Leo One USA was to share the LRPT and TIP bands, but avoid Starsys, as suggested by the Notice, a total of 420 kHz is available. Initially, when one existing MetSat is overhead, half the TIP spectrum is available or 360 kHz. When two satellites are over head, none of the TIP spectrum may be available or 300 kHz total would be available. However, the TIP bands may not be used by all of the satellites. Again, Leo

[3] If the APT bands, referred to in the Notice as being reserved for Orbcomm, were allocated to new licensees an additional 60 kHz would be available for exclusive use after 2006.

One USA needs 350 kHz to service all its requirements. Thus, for some small period of time a gateway channel could be turned off. This would be acceptable. Occasionally when the China MetSat is overhead a 50 kHz portion of the LRPT band would be unusable because of interference. Thus, at times, only 250 kHz may be available. This would be sufficient for subscriber communications and a single gateway link which would provide satisfactory utility for this limited triple conjunction period.

The Commission in the Notice has indicated it intends to move Orbcomm out of the 137.185-137.2375 band segment to the NOAA ATP channels, obstensively to avoid interference with NOAA's use of the LRPT band. Under this plan it appears that Orbcomm will end up with 290 kHz of exclusive downlink spectrum. The timing for the transitioning to the ATP bands is unclear and will block significant spectrum that otherwise would be useful. In order to accommodate this transition, Orbcomm should move immediately and time share the ATP bands with NOAA just as the TIP bands must be time shared with any new second round entrant. When NOAA begins usage of the LRPT bands in 2002 (METOP), the ATP bands must continue to be shared for a number of years until the then existing NOAA satellites all fail (probably 2007). Alternatively, Orbcomm retains its current spectrum freeing 60 kHz for supporting additional second round entry. If Orbcomm is allowed to transition to APT but at its own pace then presumably when the NOAA satellites using the ATP bands cease all operations, Orbcomm would transition into these bands. This has a likely target date of 2007 or later. By that time, a Little LEO sharing the LRPT bands will effectively be transitioning out as well because of the large constellations of Metsats using the band; presumably they must transition into the spectrum left vacant by Orbcomm or else face diminished capacity.

At this point there would exist at most 120 kHz of exclusive TIP spectrum with the diminished capability to share the LRPT band and if the spectrum vacated by Orbcomm could be used, an additional 92.5 kHz of exclusive spectrum is potentially available from 137.1825 to 137.275 MHz.

Should Meteor 3 vacate it's bands an additional contiguous 50 kHz may open up in addition to another 42.5 kHz segment. Potentially this provides a gateway and at least four additional dedicated TSD channels, if the Russians co-operate. Some lesser channel bandwidth of the order of 20 kHz are also also potentially available.

In total, in the Post 2006 time frame, there could be as much as 305 kHz of exclusive spectrum available but more likely just the 120 kHz of TIP channels.

We note that the Notice refers to the TIP channel as extending from 137.333 to 137.367 MHz rather than 137.320 to 137.380 MHz and 137.753 to 137.787 MHz rather than 137.740 to 137.800 MHz, which are consistent with the necessary channel width for the current NOAA TIP signals. The TIP signals have a necessary bandwidth of 44 kHz and a necessary channel width of 60 kHz. We have assumed the bandwidth available to a Little LEO would be consistent with the 60 kHz TIP channel bandwidth. The APT signals have a necessary bandwidth of 38 kHz. The necessary channel width includes allowances for oscillator drift and Doppler frequency shift and is 50 kHz. The LRPT signal is 72 kbps digital signal and requires a 150 kHz channel bandwidth.

A. Concurrent Time Sharing of TIP Channels and LRPT Bands

During the transition period when a Little LEO must share both the NOAA channels and the NOAA bands, the availability becomes a function of two sets of satellite constellations. One set operating in the LRPT bands and one set operating in the TIP bands. For this situation, it takes two satellites from each set to simultaneously be in contact with a Leo One USA satellite in order to fully block communications. For the purposes of evaluating this situation, an existing five satellite NOAA and an existing five satellite DMSP constellation were chosen as offering representative orbit coverages. Figure 3 provides a snapshot in time of its world wide coverage. Using this worse case of five satellites each, the availability shown in Figure 4 was evaluated. As indicated, the user availability is high. It should be noted that the availability achievable can be increased to essentially 100 percent if additional dedicated spectrum is available for a subscriber downlink.

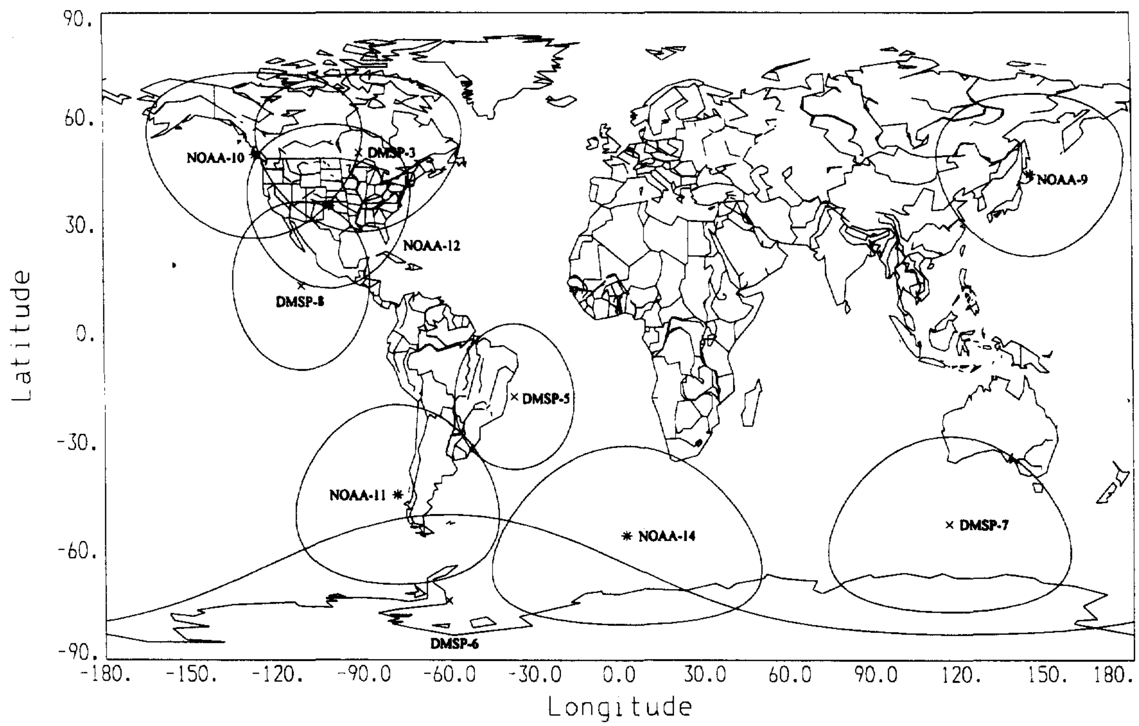

Figure 3. Extended MetSat Coverage For Transition Period Analysis.

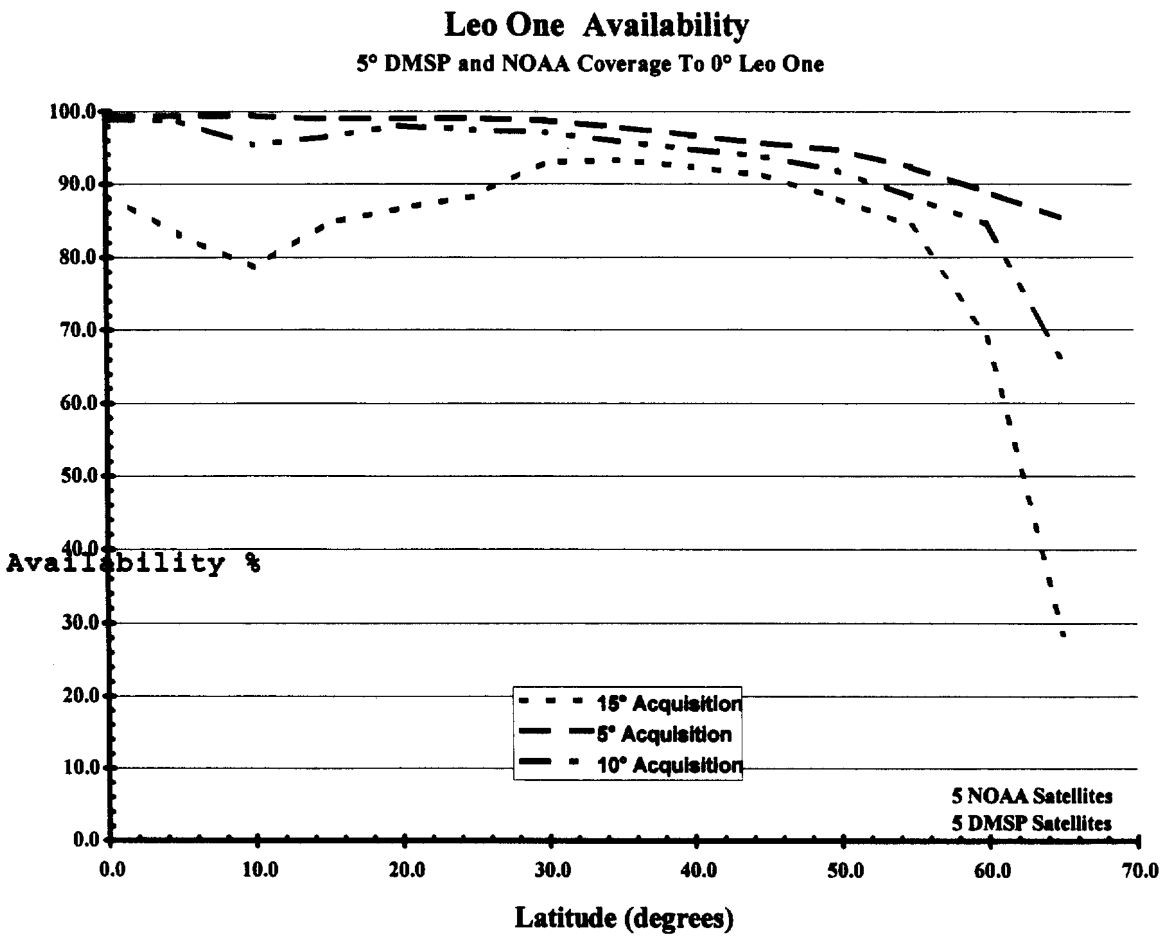

Figure 4. Availability When Sharing LRPT Bands With Five MetSats And TIP Channels With Five NOAA Satellites.

B. Impact on NOAA Community of Little LEO Transmissions When NOAA Satellites are Not in View

The NOAA satellite transmission formats and rates are sufficiently different from those of the proposed Little LEOs that NOAA receivers should not respond to the Little LEO signals. Likewise, Little LEO receivers will not respond to NOAA transmissions due to the different modulation formats and data rates. While a Leo One USA receiver may attempt acquisition of a NOAA signal carrier, the Little LEO receiver will not respond due to the lack of a CRC check sum validation, even if data rates were the same, just as it will not respond to noise signals. In this manner, its operation is transparent to the user.

The NOAA primary instruments are the Advanced Very High Resolution Radiometer (AVHRR) and the TIROS Operational Vertical Sounder (TOVS) complex. The APT modulation format is AM on a 2.4 kHz subcarrier which in turn frequency modulates the carrier. This signal operates at either 137.50 or 137.62 MHz. Eventually, these APT signals will be moved to 137.1 and 137.9125 MHz. The NOAA Analogue Picture Transmissions (APT) signals have a necessary bandwidth of 38 kHz. The necessary channel is 50 kHz which includes allowances for oscillator drift and Doppler frequency shift. The transmitter power is 5 watts into a RHCP quadri filar antenna with 0 dBci at the horizon and +4.5 dBci at nadir. This signal modulation format is unlike the more modern digital formats proposed by Little LEO applicants.

By the year 2006 the NOAA NPOESS series satellites will be launched with the APT replaced by the Low Rate Picture Transmission (LRPT) digital signal. The LRPT is a 72 kbps digital signal and requires a 150 kHz channel. Leo One USA believes this is a BPSK signal format. This data rate is much higher than proposed by any of the Little LEO systems. Thus, it is unlikely an LRPT receiver would respond to a Little LEO signal.

The Tiros Information Processor (TIP) telemetry data transmits at 137.35 and 137.77 MHz. The TIP signal has a necessary bandwidth of 44 kHz and a necessary channel width of 60 kHz.

C. 48 Hour Reset Signal is Unnecessary

The need for a 48 hour reset signal seems arbitrary and unnecessary. We assume this requirement is to ensure that the satellites are healthy and functioning properly. We do not plan that every gateway have the ability to command our satellites. While we would plan to communicate with the satellites in our constellation routinely, consistent with our orbit repeat cycle, we believe the ephemeris data necessary to ensure operation outside NOAA exclusion zones will be valid for at least seven days. Thus, we do not see the need to communicate with every satellite every 48 hours. We would intend that if a satellite had not heard from its command center within seven days in order to receive a new set of ephemeris exclusion zone data, that it would then cease transmissions until such time that a valid upload is received.

Should a satellite fail, the ground network of gateways would presumably detect this situation and report it well within any 48 hour period. If not, the NOCC command center would make this determination.

We would propose insteaa that a series of dual redundant fail safe procedures be implemented to ensure the satellite does not operate in a NOAA exclusion zone. These procedures can best be determined by each Little LEO system. For example, if the NOAA band transmitter failed to turn off, a transmit timer can be implemented to ensure that it is turned off, say, every rev with a modem off switch separate from a power amplifier power switch. Error protected memory with memory scrubbing can be used for critical command functions to preclude latchup or upset errors. Command encryption should be used to preclude tampering with the satellite operating modes. Command authentication should be implemented on each command before execution, watch dog timers should be implemented on key control computers, etc. These are all things any prudent, reasonable and professional satellite designer would implement in the normal course of a design. While Leo One USA's satellites may be small, they hardly lack in sophistication. The successful operation of the satellites, the constellation, and the ability to provide reliable services require high quality and reliability of the space segment.

We plan to shut our satellite transmitters off automatically during idle periods to conserve prime power. Thus, we expect the transmitters to be off a significant portion of the time, especially over ocean areas. To ensure against latchup situations where the transmitter might otherwise be stuck on, we intend to implement a fail-safe timer as alluded to above. The exact time duration remains to be determined, which will be based on the average power budget for the satellite. At this time we believe a one rev cycle time will be satisfactory.

The impact of a Rogue Leo One USA satellite is shown in Figure 5. Here we define a Rogue satellite to be a satellite with its transmitter stuck on such that it will interfere with a NOAA/DMSP satellite. We note that the impact of a Rogue satellite to the DMSP user availability is less than 0.5 percent as shown in Figure 5. We note that the corresponding percent of the time that the Rogue satellite interferes with a ground DMSP/NOAA user as a percent of a NOAA pass is less than 6.7 percent, assuming a five NOAA/DMSP satellite constellation. Because of the low frequency of interference, the imposition of a 48 hour timer reset does not seem justified. Rather, prudent design decisions as discussed above should suffice.

More over, with doubly redundant fail-safe methods and typical electronics reliability (probability of failure of less than 0.001 over 5 years), it is straight forward to show that the probability of the Rogue event due to failure as shown in Figure 5 is less than 5 $\times 10^{-8}$ in five years for the entire Leo One USA constellation. Because of the low probability of this Rogue Satellite interference, the imposition of a 48 hour timer reset does not seem justified and better left to the satellite designers.

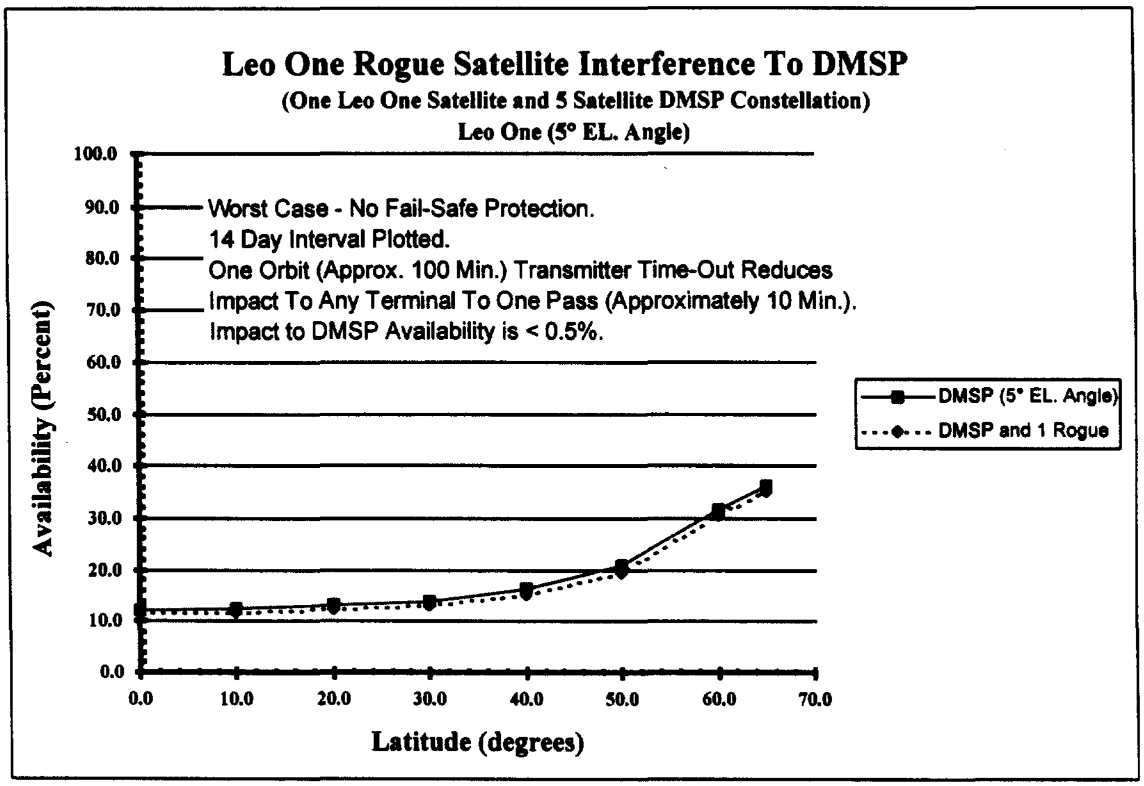

Figure 5. Impact of Rogue Satellite on NOAA/DMSP Availability.

If such a timer is required, it can be verified on orbit during an initial test and checkout phase. It can also be verified through inspection of the build documentation.

We would not like to see our operations interrupted for periodic on orbit testing. The impact to NOAA is so slight that we view this as an unjustified imposition.

D. Metsat Earth Stations Operating at 137 - 138 MHz Should be Protected Only While the Associated Satellites are Located at Elevation Angles of Five Degrees or Greater

Consistent with applicable functional requirements, performance factors, and international frequency sharing criteria, meteorological earth station receivers operating at 137-138 MHz and 401.5 - 401 MHz should be protected only while the satellites are at elevation angles of 5 degrees or above. There generally are no functional requirements to receive "direct readout" data[4] from meteorological satellites at elevation angles less than five degrees because the associated geographic areas are too limited and distant to indicate current and evolving meteorological conditions. Even if reception of data at lower elevation angles were desired, NOAA transmissions cannot be reliably received below 5° to 10° elevation due to multipath and local obscura just as a Little LEO's transmissions would not be reliably received. Accordingly, a minimum elevation angle of five (5) degrees has been specified for interference and frequency sharing criteria adopted internationally for meteorological-satellite earth stations. Reference Appendix D for a discussion of the ITU recommendations.

[4] "Direct readout" data consists of the data that are collected by sensors on the satellite and transmitted in real-time.

In light of the functional requirements and performance limitations, the performance and interference criteria adopted internationally for meteorological satellite services are specified for elevation angles of five (5) degrees and higher. Specifically, for the 137-138 MHz and 400.15 - 401 MHz bands, Recommendation ITU-R-SA.1025-1 specifies a meteorological satellite performance objectives for 99.9% of the time that the elevation angle exceeds five (5) degrees. For protection of these transmissions, Recommendation ITU-R SA.1026-1 specifies that the total interfering signal power should not exceed certain levels during reception at elevation angles exceeding five (5) degrees. Both of these Recommendations were based on United States input documents to the ITU Working Party 7C, which were endorsed by the worlds meteorological satellite experts.

We agree that the flux density from any of the FDMA Little LEO applicants may result in unacceptable interference to NOAA user terminal operation whenever the Little LEO satellite is within the line of sight to the NOAA terminal and that terminal is receiving a NOAA downlink transmission on the same frequency. This is due in part to the use of NOAA terminal hemispherical receiving antenna coverage patterns (These patterns typically fall off rapidly near the horizon). Again, NOAA transmissions cannot be reliably received below 5° to 10° elevation due to multipath and local obscura just as a Little LEO's transmissions would not be reliably received. Thus, a 0° Little LEO footprint overlap with a 5° NOAA satellite coverage footprint would seem appropriate for the calculation of a Little LEO exclusion zone, consistent with the frequency sharing criteria adopted internationally for meteorological-satellite earth station receivers.

Requiring a 0° Little LEO footprint to 0° NOAA satellite coverage exclusion zone would be excessive. This directly impacts the Little LEO commercial service availability. The typical impact to Leo One USA using the NOAA bands is summarized in Table 2. For instance, the difference to Leo One USA of a 0° to 0° coverage exclusion zone and 5° NOAA to 0° Leo One USA coverage exclusion zone is computed as reducing the availability from 77% to 68%.

Blockage of the NOAA channels is computed here as occurring when ever there are two NOAA satellites overlapping a Leo One USA satellite coverage; this is under the worse case assumption that the NOAA satellites traveling in close proximity will use differing NOAA channels (and, thus, both available channels). It is also assumed that the frequencies used by the NOAA satellites and their ephemeris will be published by NOAA and made available so that any Little LEO operating in this band can use alternative frequency bands when a singular NOAA satellite is within its horizon footprint. Figure 6 is a plot of the Leo One USA availability as a function of Latitude. For this analysis, five DMSP satellites currently in orbit have been used to define a future prototypical 5 satellite constellation. The Leo One USA operational coverage is here defined as 15° acquisition elevation angle.

Table 1 Availability Impact Of Exclusion Zone To LEO-One @ 40° Latitude.

Exclusion Zone	Constellation Availability
None	100%
0° Leo One to 10° NOAA	84%
0° Leo One to 5° NOAA	**77%**
0° Leo One to 0° NOAA	68%

15° Leo One Acquisition Angle

The difference in the size of the exclusion zone coverage for 0, 5 and 10 degree elevation angles is shown in Figure 7, Figure and Figure . The size of the exclusion zone increases by nearly 15% for a decrease in NOAA elevation angle from 5° to 0°.

Leo One USA believes a 5 degree NOAA operational coverage zone to a 0° Leo One USA coverage footprint is a reasonable requirement.

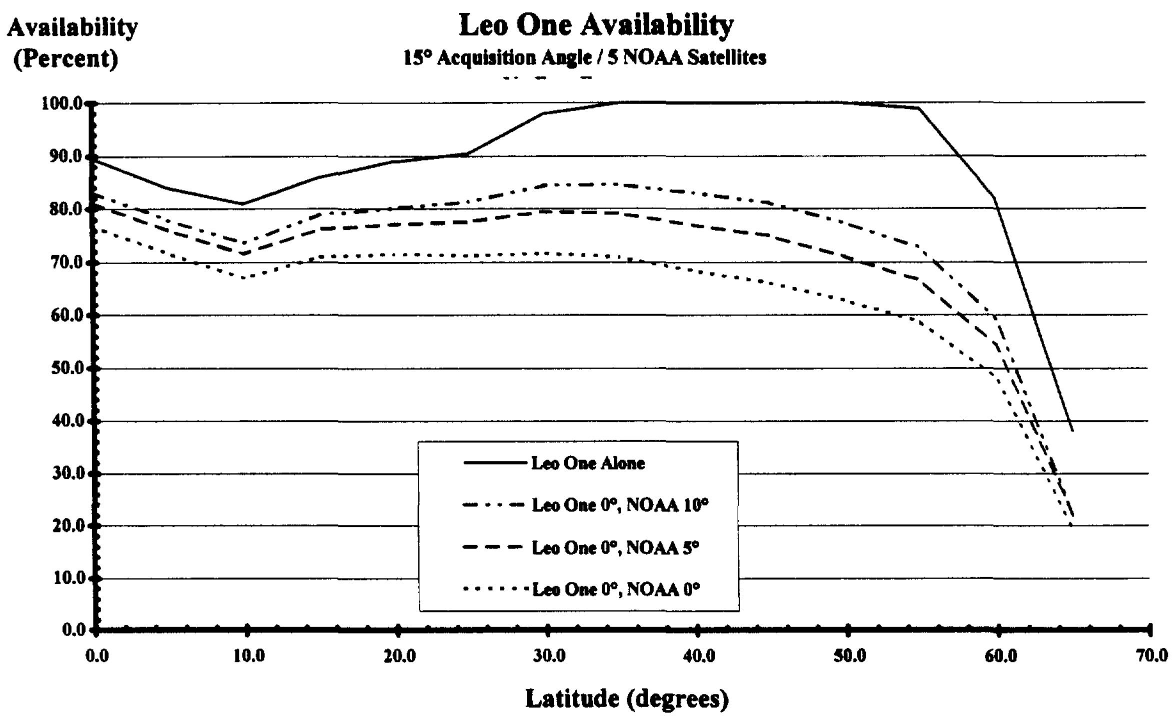

Figure 6. Leo One USA Availability For 0, 5 and 10 Degree NOAA Coverage With 0 Degree Leo One USA Coverage Avoidance.

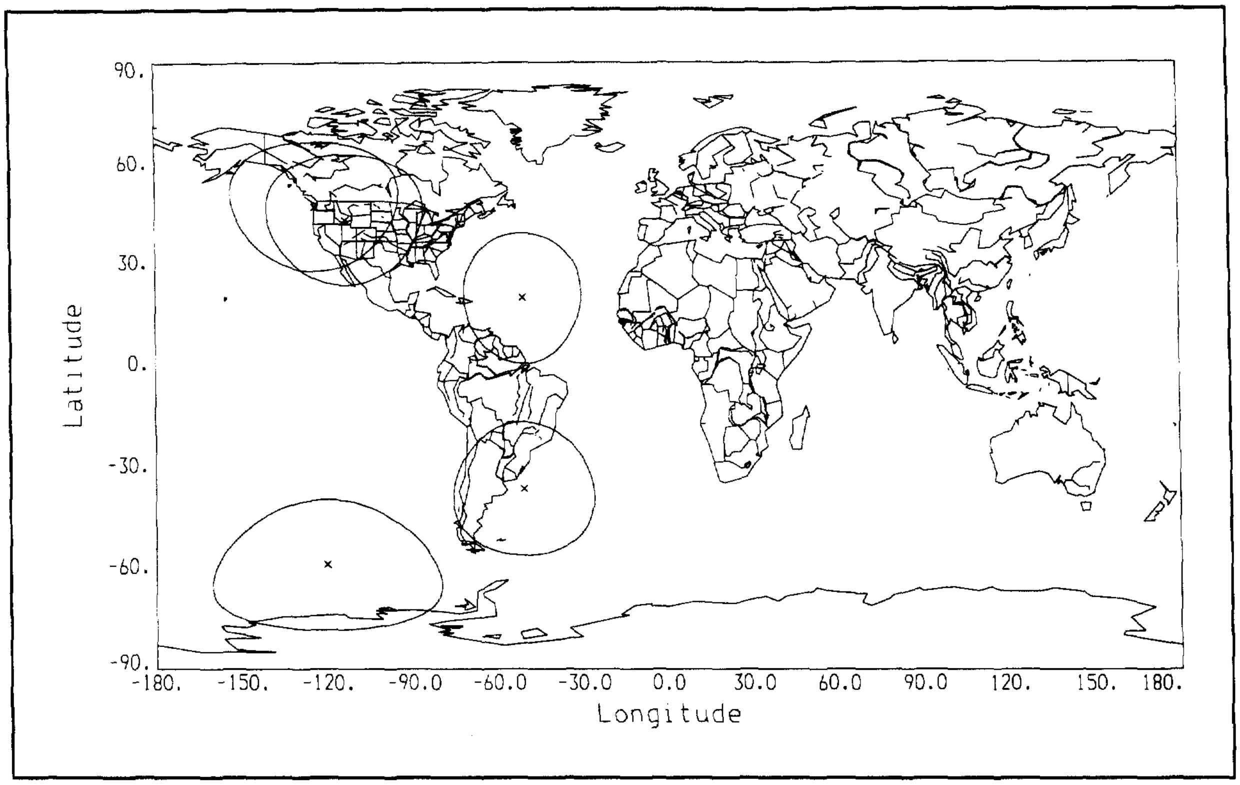

Figure 7. NOAA Coverage Footprint For 10 Degree Elevation.

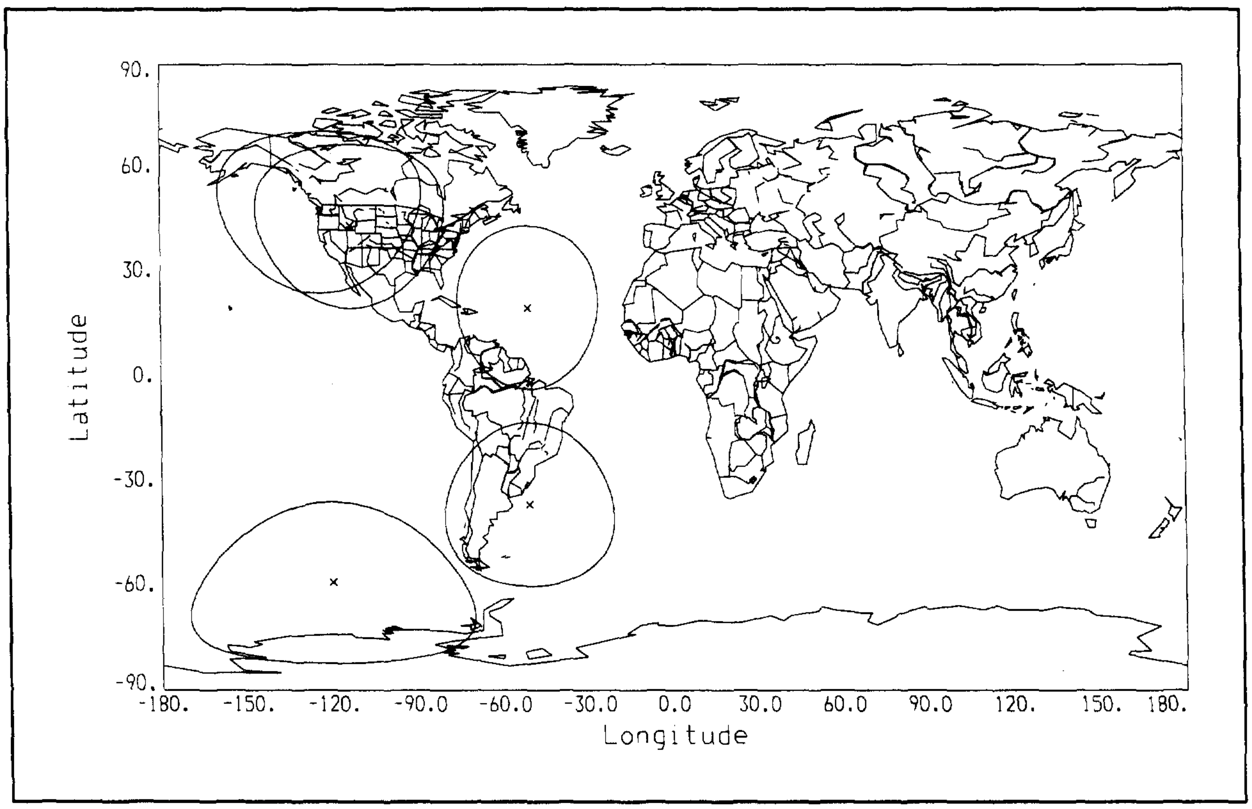

Figure 8. NOAA Coverage Footprint For 5 Degree Elevation.

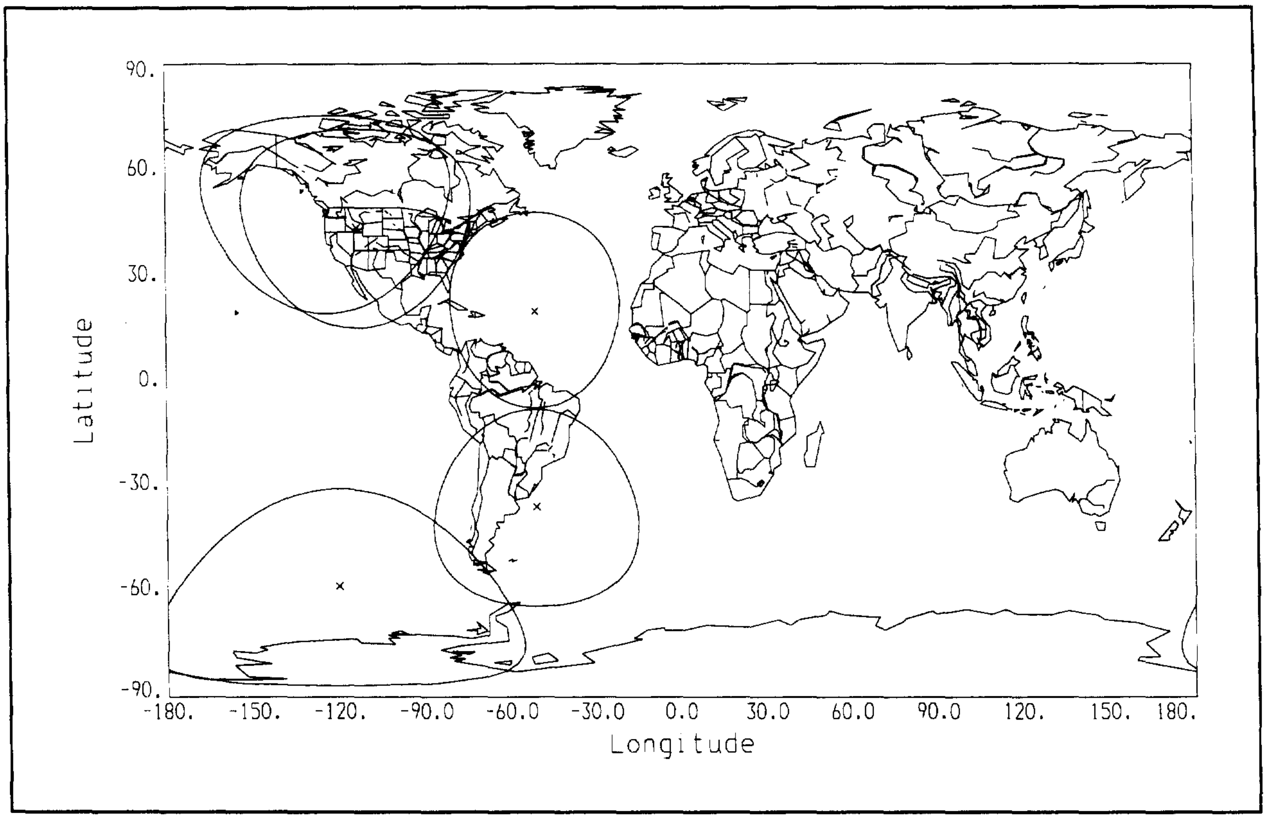

Figure 9. NOAA Coverage Footprint For 0 Degree Elevation.

2. <u>Sharing with DMSP MetSats in the 400.15 - 401 MHz Band</u>

The DMSP MetSat band can be shared on a non-interference basis to DMSP using a frequency avoidance concept. This simplified frequency sharing concept requires the Little LEO satellites to step or hop to the opposite DMSP MetSat band segment whenever a MetSat coverage footprint overlaps that of a Little LEO satellite horizon. The coincidence times are readily precomputed and frequency selection instructions can be loaded into each satellite to span the duration of element set validity.

It should be noted that for a five satellite DMSP system, the potential exists for two DMSP coverage zones to overlap a Little LEO horizon footprint as shown in Figure 10 over CONUS. These coverage contours were obtained by using five of the DMSP satellites currently in orbit as representative of future orbital coverage. This overlap will result in total blockage of the Little LEO System in those areas where the dual DMSP overlap occurs. Worse still, any two DMSP satellites within the horizon coverage of a Little LEO satellite will potentially result in a blockage situation. This worse case analysis assumes the two DMSP MetSats in close proximity will use both portions of the band so as not to interfere with themselves, leaving Leo One USA without any available spectrum during this overlap period.

Under the assumption that the DMSP downlink frequencies in use will be provided to the Little LEO operator, it is possible to estimate user availability for the band hopping approach described. The availability to Leo One USA users is a function of the exclusion zone size as discussed in the response to Notice at Paragraphs 61 and 71. Table 2 provides a summary of the impact of the exclusion zone elevation angle impact to availability. Figure 11 shows the availability as a function of latitude.

Table 2. LEO-One Availability @ 40° Latitude.

Exclusion Zone	**Constellation Availability**
None	*100%*
0° Leo One to 10° DMSP	84%
0° Leo One to 5° DMSP	77%
0° Leo One to 0° DMSP	68%

15° Leo One Coverage Angle

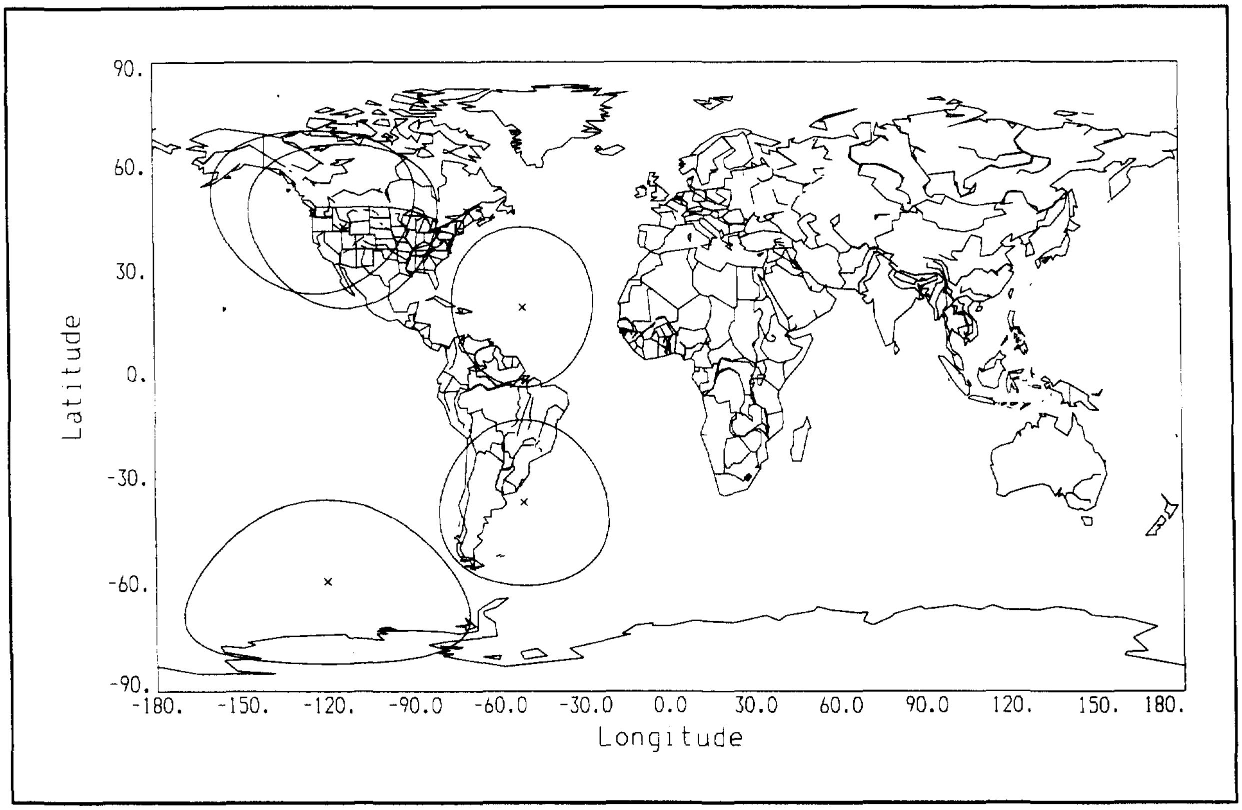

Figure 10. DMSP Five Satellite Constellation Coverage For 5° Elevation Footprint.

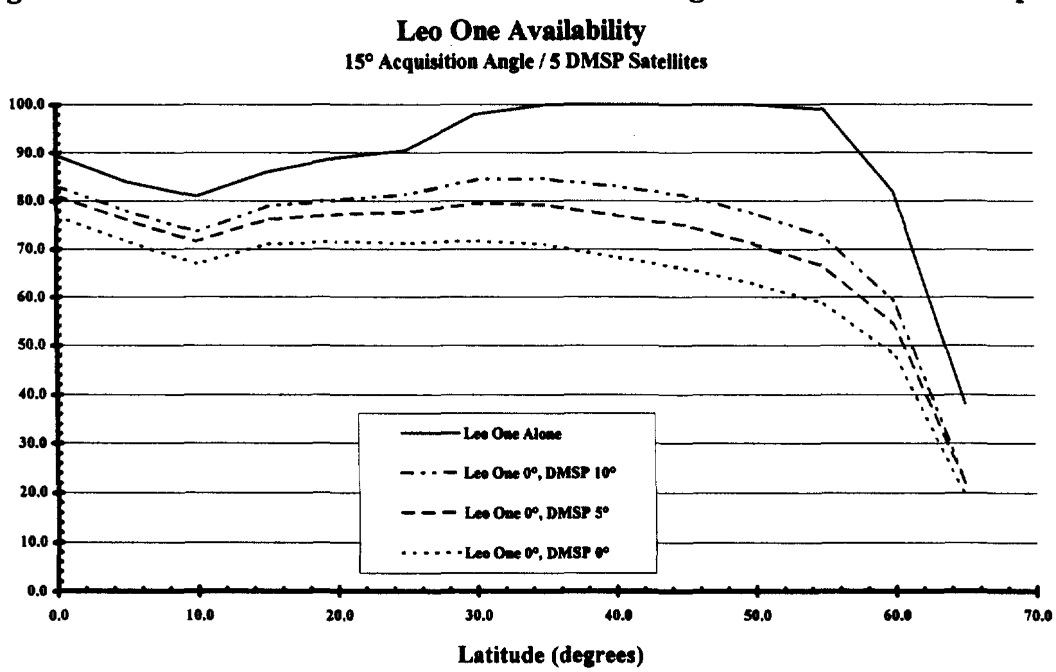

Figure 11. Availability For 15° Leo One USA Coverage, 5 DMSP MetSats.

As the above material demonstrates, the requirement for near real time service cannot be realized by Little LEO System 3.

A. <u>DMSP Earth Stations Operating in the 400.15 - 401 Mhz Band Should be Protected Only While Associated Satellites are Located at Elevation Angles of Five Degrees or Greater</u>

Protection of DoD MetSats below 0° elevation angle is not warranted. Even zero degrees is beyond any operational requirements and capabilities of the DMSP satellites and their ground terminals. On the other hand, the impact to a Little LEO availability is significant. For instance, not only do the NOAA/DMSP orbits coincide with the daylight busy hours of each region, in many cases the satellite are traveling in close proximity to each other. This has the effect of potentially blocking both the DoD downlink bands at 400 MHz. Figure shows such a case where two DMSP satellites are over CONUS. This plot is for 10 degree elevation coverage contours. Figure shows the increased coverage and blockage for 5 degree coverage while Figure shows the increased coverage at 0 degrees elevation angle. The denied Little LEO coverage area increases by 40 percent from 10° to 0° coverage. This increase is of the order of 15% for 5° to 0° degrees coverage zones. As described in Appendix D, DMSP operation below 10 degrees is marginal and below 5 degrees is unlikely. Leo One USA believes a 5 degree DoD/DMSP operational coverage zone to a 0° Leo One USA coverage footprint is a reasonable requirement. If any Little LEO is to make use of these band, it is also reasonable that the DoD provide the frequencies use by each satellite and its ephemeris such that the Little LEO satellite operator can use those frequencies that are not in conflict with those DoD/DMSP satellites that overlap its coverage.

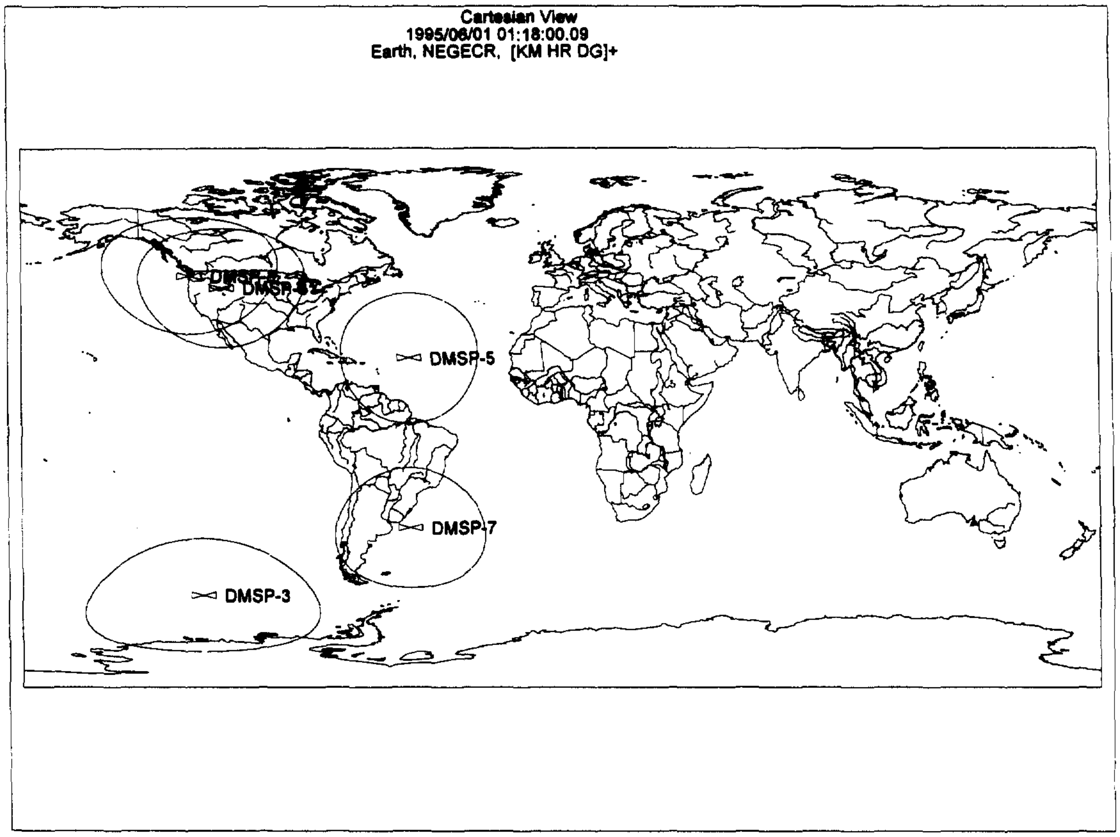

Figure 12. DMSP Coverage Footprint For 10 Degree Elevation.

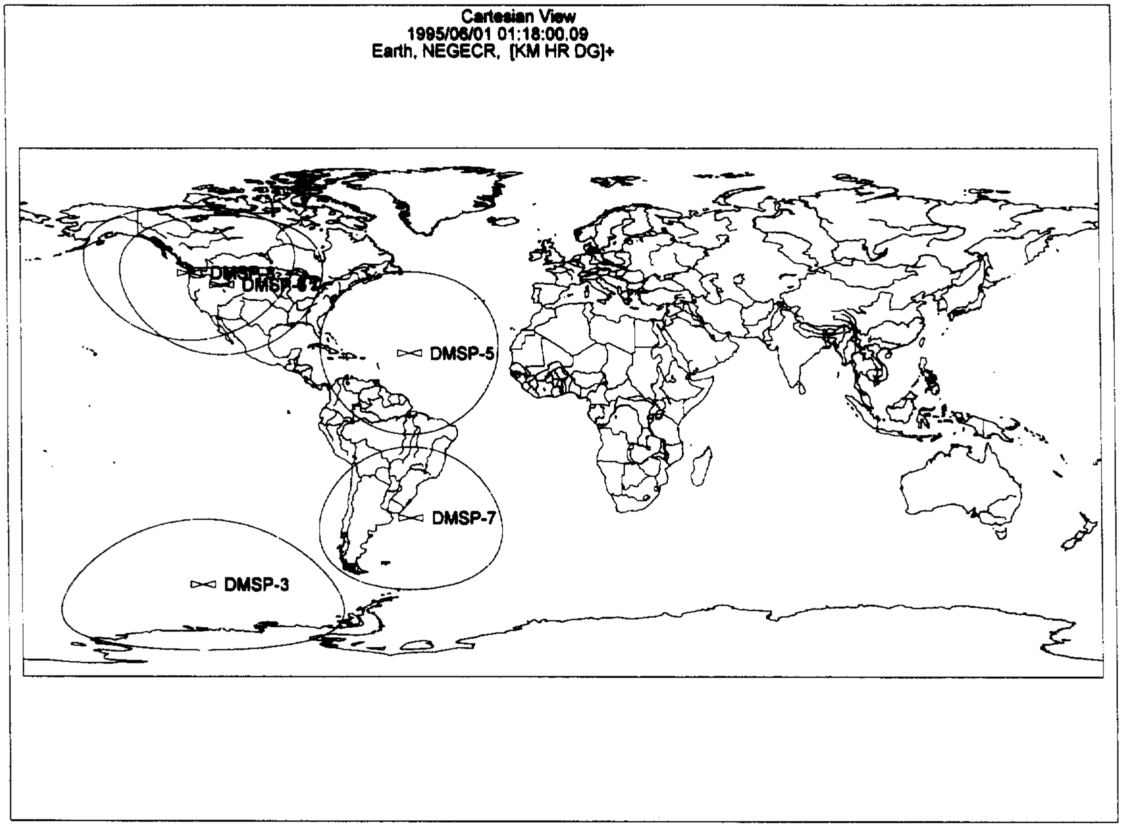

Figure 13. DMSP Coverage Footprint For 5 Degree Elevation.

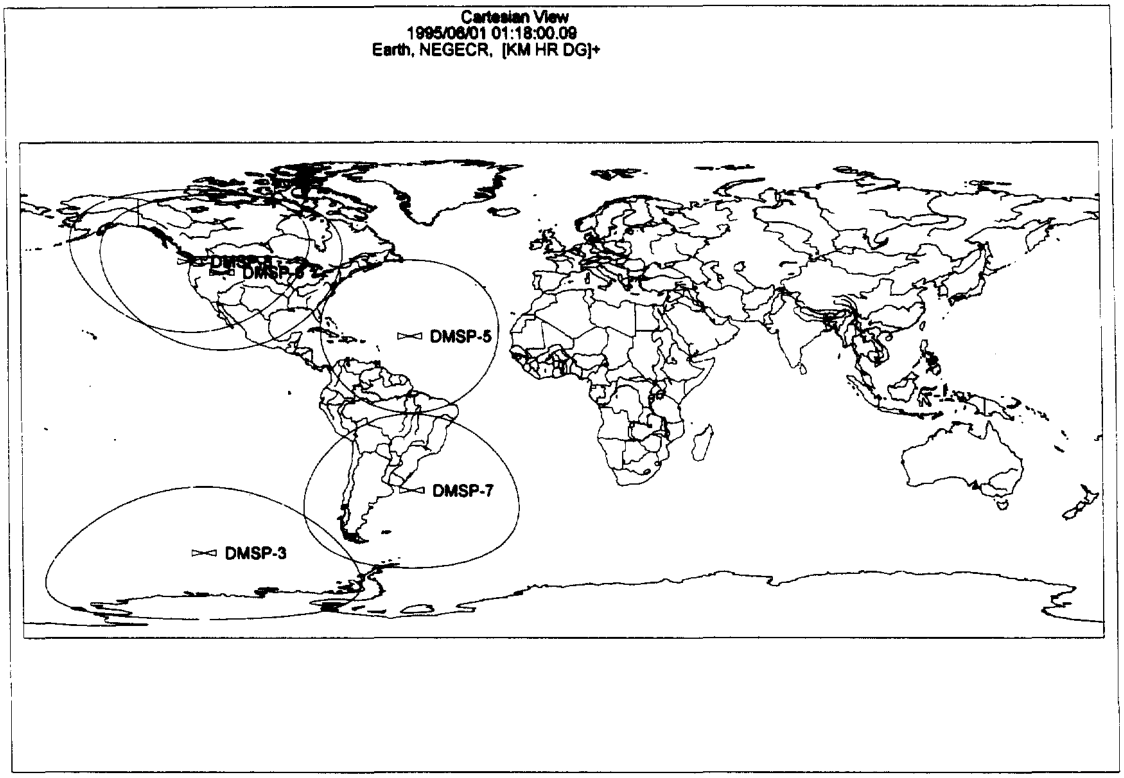

Figure 14. DMSP Coverage Footprint For 0 Degree Elevation.

Figure 15 shows the impact of the DMSP protection coverage on Leo One USA Availability. The top curve shows the availability of the Leo One USA constellation for a 15 degree coverage zone assuming no frequency conflicts. This availability is by design 100 percent over CONUS. The availability drops to 84 % for 10° DMSP coverage protection. At 5° DMSP protection coverage the availability drops to 77 % while for 0° DMSP protection coverage the Leo One USA availability drops to 68 percent. Even for 5° DMSP protection, the 77 percent availability impacts planned services.

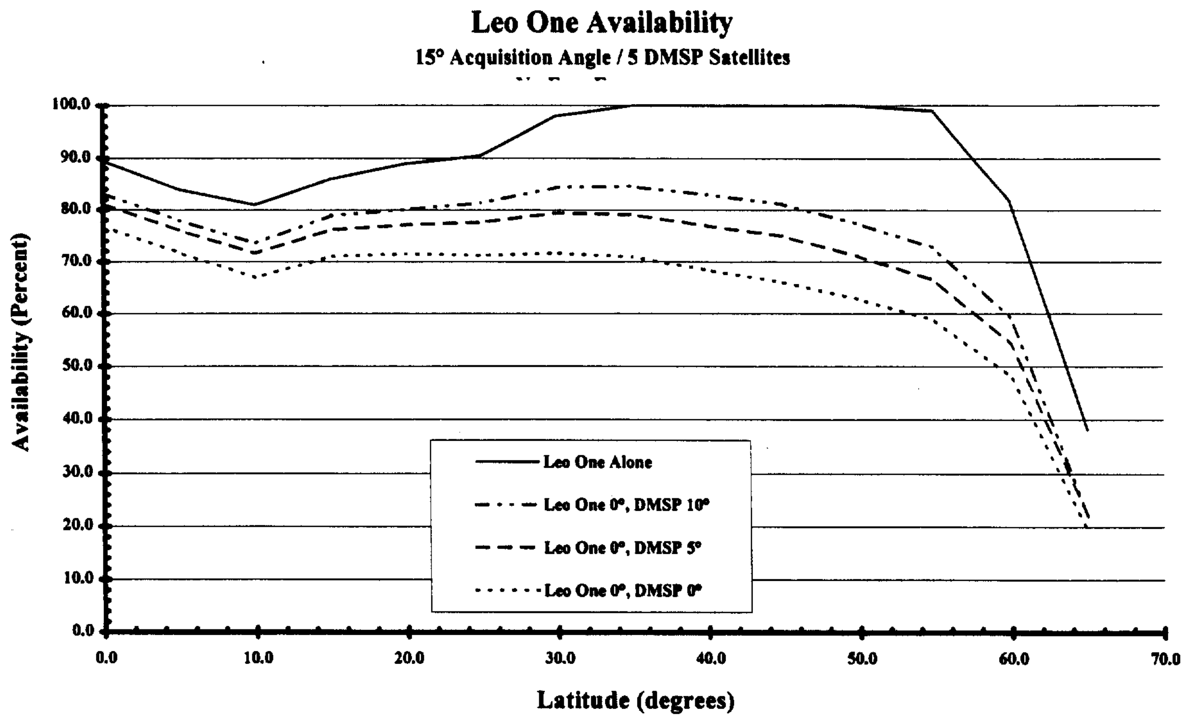

Figure 15. Leo One USA Availability For 0, 5 and 10 Degree DMSP Coverage With 0 Degree Leo One USA Coverage Avoidance.

B. <u>NVNG MSS System Testing Requirements</u>

The requirement for testing the systems ability to change downlink frequency within 90 minutes in these bands up to four times a year seems excessive, arbitrary and an unnecessary imposition to the operation of a commercial communication systems. Once a year would seem more than adequate under the supposition that the DoD wishes "to ensure that the system operator can implement the frequency change and that there are no equipment or system based problems in doing so."

It should be noted that for a constellation such as Leo One USA, that frequency changes will be continually required as satellites approach the radio horizon of a DMSP satellite as described in our comments to Paragraph 70. This requirement results since each DMSP band individually does not support the entire spectrum requirements of Leo One USA's downlinks. Thus, as a Leo One USA satellite horizon approaches the DMSP footprint operating in the same band, it must change to the opposite frequency band. In so doing, it must temporarily select a frequency that is not in use with any other Leo One USA satellite that also overlaps its radio horizon. At times there can be up to nine other Leo One USA satellites in contact with any given Leo One USA satellite's horizon coverage footprint. This is not a problem to Leo One USA under normal circumstances since different frequencies are assigned to each orbit plane. Ordinarily any required frequency changes are planned well in advance so the entire constellation frequency plan will change at the same time using stored commands. Immediate changes as stations contact a command site will lead to conflicts that could preclude normal operations in Leo One USA coverage overlap regions.

We also note that assuming the DMSP frequency assignment change requirement arises naturally from real world operational requirements, it would seem it would be executed occasionally during normal military operations and, thus, not need to be tested at random so frequently. We would propose to require at most an annual test during those years when an operational change has not occurred, and preferably not during peak traffic periods over principal market areas.

The operational motivation for unscheduled frequency changes is not clear, except in response to an abrupt on set of local interference in some geographic area. Overlapping DMSP footprint coverage can be predicted long in advance and frequency changes regularly scheduled and coordinated with an NVNG satellite Constellation Operations Control Center (COCC). We also suspect that if intentional jamming were the motivation for changing frequencies, the proposed frequency change would be totally ineffectual. A jammer could quite easily monitor the bands for the downlink and instantaneously jam the channel or, alternatively, it could jam both channels simultaneously as satellites enter its horizon.

It is possible the interference may only become apparent one rev in advance of the satellite coverage for a given area and the DoD space command network is capable of responding within that period. However, this would seem to be a rare event. For such a rare event a requirement to have a world wide network of terrestrially interconnected command stations for a commercial NVNG system is a significant burden.

C. <u>90 Minute Command Station Requirements</u>

While it is theoretically possible to command the entire Leo One USA satellite in 90 minutes, a world wide network of command stations is required. Leo One USA did not intend to locate command stations outside the U.S. In particular, we did not intend each international gateway to have a satellite command capability. We believe a network of command stations operated within CONUS can provide a response time of less than 11 to 14 hours for orbit inclinations of approximately 50 degrees. A network of command stations operated from U.S. Soil can reduce this to under 8 hours. Additional command stations in foreign locations are necessary to reduce this to meet a 90 minute command time. In general, it is very difficult to command a constellation in less than its orbital period. For Leo One USA, its orbital period is approximately 104 minutes. A command requirement of the order of 104 minutes results in a more economically satisfactory solution. We believe a "one orbital period" requirement is the most reasonable approach to satisfying this DoD requirement together with a 15 minute command generation time allowance

It is possible to create a "fence" of four ground stations extending from North America through South America that can guarantee contacting every satellite in the constellation over one orbit period. However, since an orbital revolution takes about 104 minutes, some satellites, will not be seen in 90 minutes or less.

Given no warning, and with automated command generation software, it is estimated that it may take 10 to 15 minutes for the command streams to be generated and transmitted to the appropriate remote command stations. This assumes the only inputs required in real time are the new frequency bands in use by up to five DMSP satellites. Thus, realistically, this leaves not 90 minutes to recommand the satellite network, but 75 to 80 minutes to meet the DoD requirement. We believe a "one orbital period" requirement is the most reasonable approach to satisfying this DoD requirement together with a 15 minute command generation time allowance which would result in a 120 minute response time.

The costs of generating and validating this software, while not insignificant, are minor compared to the total network operations software requirements. Likewise, it is anticipated that dedicated leased lines or VSAT networks will be required to link the COCC and the remote command sites.